a two-cycle operation with switching done by input voltage in the shape of a rectangular wave (sinusoidal wave can also perform the switching). Periodic DC pulses over triodes ΠT 1 and ΠT2 (Fig. 4a) can be represented as a sum of DC current $I_0/2$ and I as a rectangular wave with amplitude $I_0/2$. AC of both arms are in antiphase. On the other hand, positive current direction I_1 and I_2 are opposite, with reference to points ab (Fig. 4 b). Consequently constant components of both currents add and pass through point b while equivalent AC oscillator is connected between points a and c, i.e., directly or through transformer, and is subconnected to the circuit. This two-cycle diagram has expressions somewhat different from (4) and (6):

$$I_0 = E/(r + 0,2R), \qquad (7)$$

$$\gamma = 0,2R/(r + 0,2R), \quad (2/\pi^2 \simeq 0,2). \qquad (8)$$

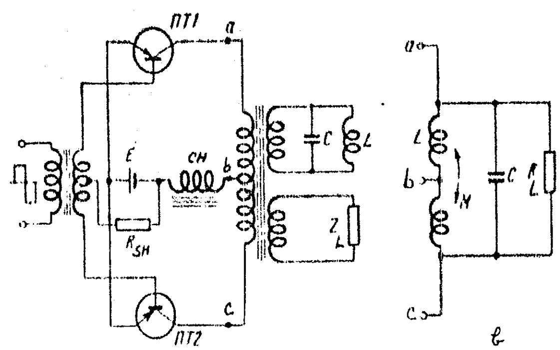

Fig. 3. Circuit diagrams of an oscillator with transistor: (a) transformer-connected load; (b) load connected without transformer.

As in the basic diagram, the above is designed for

Harmonic Oscillator With Keying Elements

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γ is the efficiency rate; P is power consumed from emf source. It follows from these equations that the oscillator, working on the basic frequency, can be represented as an equivalent oscillator whose effective emf and inner resistance are $\pi E/2\sqrt{2}$ and r/0.8, respectively. Output voltage of the oscillator (in relative units) changes with a change in the load according to the expression

$$\Delta U/U = (1-\gamma)\Delta R/R.$$

2. Practical circuit diagrams of oscillators. Transistor triodes are excellent keying elements: internal resistance of powerful triodes (П4-type) is a fraction of an ohm. A diagram is shown in Fig. 3 a,b.

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where U_{ab} is the constant component of voltage U_{ab}; r is the total internal resistance of the source, the choke, and the keyer. On the basis of (1) one can write for a high-Q circuit (disregarding harmonics):

$$\overline{U}_{a\text{б}} = \frac{8 I_0 R}{\pi^2} \frac{\cos\varphi}{\sqrt{1+\left(\frac{2\Delta\omega}{\omega}Q\right)^2}}. \qquad (3)$$

From (2) and (3), I_0 can be determined. In the case of resonance (which alone is considered further)

$$I_0 = E/(r + 0{,}8R), \qquad (4)$$

Power P_R in the load resistance R is

$$P_R = EI_0 - rI_0^2 = \gamma P, \qquad (5)$$

WHERE

$$\gamma = 0{,}8R/(r + 0{,}8R), \qquad (6)$$

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Harmonic Oscillator With Keying Elements

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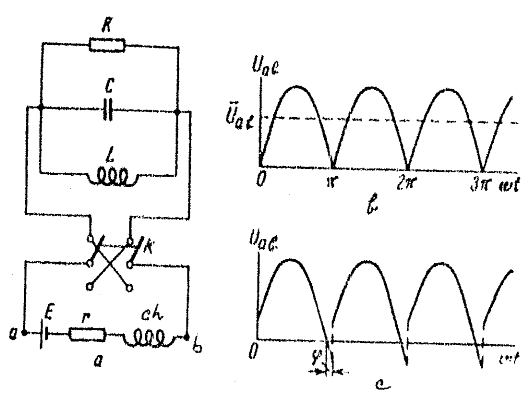

Fig. 2. (a) Basic diagram of oscillator; (b) shape pf voltage curve between points ab when $\varphi = 0$; (c) ditto when $\varphi > 0$.

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This method of exciting harmonic oscillations in the circuit is the base of the proposed generator, the circuit diagram of which is shown in Fig. 2a. Here the key having a frequency near or equal to that of the circuit commutates the current source, consisting in a source of direct emf E and choke L_{ch}. As a result, voltage between points a and b is quasi-rectified (Fig. 2b and c). The constant current component is determined from expression

$$E = \overline{U}_{al} + rI_0, \quad (2)$$

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parallel, a voltage is developed which can be expressed as a series of harmonic components:

$$U \simeq \frac{4I_0R}{\pi}\left[\frac{\sin(\omega t + \varphi)}{\sqrt{1+\left(\frac{2\Delta\omega}{\omega}Q\right)^2}} - \frac{\cos 3\omega t}{2\cdot 4\cdot Q} - \frac{\cos 5\omega t}{4\cdot 6\cdot Q} - \dots\right], \qquad (1)$$

WHERE

$$\varphi = -\operatorname{arc\,tg}\frac{2\Delta\omega}{\omega}Q; \quad Q = R\sqrt{C/L}.$$

A somewhat exaggerated shape of the voltage curve is shown in Fig. 1 (for the case φ-0). At a sufficient Q level this curve is nearly harmonic (harmonics coefficient $k \simeq 1.7/Q$)

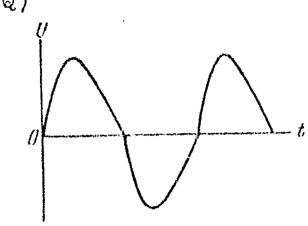

Fig. 1. Shape of voltage curve in a circuit excited by rectangular current pulses.

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parallel, a voltage is developed which can be expressed as a series of harmonic components:

$$U \simeq \frac{4I_0R}{\pi}\left[\frac{\sin(\omega t+\varphi)}{\sqrt{1+\left(\frac{2\Delta\omega}{\omega}Q\right)^2}}-\frac{\cos 3\omega t}{2\cdot 4\cdot Q}-\frac{\cos 5\omega t}{4\cdot 6\cdot Q}-\dots\right], \quad (1)$$

WHERE

$$\varphi = -\operatorname{arc\,tg}\frac{2\Delta\omega}{\omega}Q;\quad Q = R\sqrt{C/L}.$$

A somewhat exaggerated shape of the voltage curve is shown in Fig. 1 (for the case $\varphi = 0$). At a sufficient Q level this curve is nearly harmonic (harmonics coefficient $k \simeq 1.7/Q$)

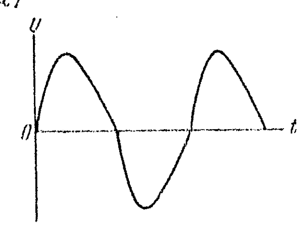

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Fig. 1. Shape of voltage curve in a circuit excited by rectangular current pulses.

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AUTHOR: Berestovskiy, G. N.

TITLE: Harmonic Oscillator With Keying Elements

PERIODICAL: Radiotekhnika i elektronika, 1960, Vol 5, Nr 3, pp 471-477 (USSR)

ABSTRACT: Modern generators of harmonic oscillations using electron tubes or semiconductors operate as a rule under class B or C operating conditions. The internal resistance of the active element must be much higher than the resonance resistance of the circuit. Considerable energy is lost in the active element. More advantageous is the keying operation under which the resistance of semiconductors, when open, is minimum. While circuit diagrams for this type of oscillators (class D) appeared only recently, there are none for generators of harmonic oscillations with keying elements. 1. Basic diagram. When a rectangular wave with amplitude I is applied to an oscillation circuit consisting of L, C, and R connected in

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94,6,1161 (1954); R. Pritchard, Frequency Variations of Current Amplification Factor for Junction Transistors, Proc. I.R.E., 40,11,1476 (1952).

ASSOCIATION: Department of Physics, Government University imeni M. V. Lomonosov at Moscow, Chair of Oscillation Theory (Fizicheskiy Fakul'tet Moskovskogo Gosudarstvennogo Universiteta imeni M. V. Lomonosova, Kafedra Teoriyi Kolebaniy)

SUBMITTED: May 13, 1959

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the actual characteristic with sufficient accuracy. (3) The duration of the front edge for rectangular-shaped base pulse current can be calculated with 10-15% exactness. The trailing edge duration, as calculated, is shorter than the actual. Empirical formula:

$$\xi_{з} = \xi_{з\,\text{теор}}[1 + 0{,}25(d - d_0)]$$

corrects the calculations to approximately 10-15% accuracy. The error increases with increase of input current. (4) Disagreement between theoretical and experimental results is basically due to the influence of the radial electrical field in the base, which was not considered at the derivation of the basic equation. There are 7 figures; 6 references, 2 Soviet, 3 U.S., 1 Japanese. The U.S. references are: W. M. Webster, The Variations of Junction Transistor Current Amplification Factor With Emitter Current, Proc. I.R.E., 42, 6, 914(1954); E. S. Rittner, Extension of the Theory of the Junction Transistor, Phys. Rev.,

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above for plane triodes. But in fused triodes (i.e., type П6) the emitter and collector have lens-type contours with varying thickness along the radius, which causes an increase of the effective base width, and of the coefficient of proportionality between charge Q and current I_k, especially pronounced in small triodes. The following conclusions are drawn concerning the operation of the plane transistor triodes: (1) The basic Eq. (1) describes with sufficient accuracy transient processes over a wide range of currents. It permits the qualitative evaluation of the nonlinear dependence of the transient processes in triodes in a circuit with common base, on the triode currents. The influence is small, and therefore the calculations of these processes can be made in linear approximation. More exact is the equation for the case when the base current is the input current. (2) The equation of static dependence $I_k = f(I_b)$ derived from (1) describes

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the potential difference in the base along the radius is found:

$$\Lambda \Delta u = \frac{I_b'}{I_k} \frac{r^2}{W^2}. \qquad (22)$$

Hence, the current distribution density is:

$$j_p(r) = j_p(0)\, e^{\Lambda \Delta u}. \qquad (23)$$

The variable j_p (0) is connected to the current I_k by relationship:

$$j_p(0) = \frac{I_k}{\pi r_e^2} \frac{\Lambda \Delta u (r_e)}{e^{\Lambda \Delta u (r_e)} - 1}. \qquad (24)$$

The irregularity of current density distribution is determined by $\Lambda \Delta u$. For slow processes where $dQ/dt \ll I_b$ the magnitude of $\Lambda \Delta u$ is inversely proportional to the static coefficient of amplification β. The influence of radial field was analyzed

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$$\frac{du}{dr} = j(r)\rho(r), \qquad (20)$$

where j(r) is average density of radial electron current in the base; $\rho(r) = 4/j_p \Lambda W \; (\Lambda = q/kT)$ is average conductivity of base (assuming linear distribution of hole concentration in the base); j_p is density of hole current in base. Neglecting recombination it may be stated:

$$j_p = \frac{I_{\text{к}}}{\pi r_e^2}, \quad j = j_p \frac{I_b'}{I_{\text{к}}} \frac{r}{2W}. \qquad (21)$$

Here r_e is emitter radius; $I_b' = I_b - I_{SR}$ is part of base current flowing through cylindrical surface of W width and radius r_e. From (20) and (21) integrating,

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П6 triodes proves a good agreement between experiment and theory, with the maximum difference not exceeding 2-5%. 3. Discussion of Results and Conclusions. The difference between theoretical and experimental data can be explained by the rigid limitations imposed at the derivation of Eq. (1), calling for a similarity of hole concentration distribution in the base for different current strengths. In actual triodes this similarity does not exist; the major reason for this is the influence of the radial component of the electrical field E_r, the magnitude of which depends nonlinearly on Q. An exact solution of the radial field is connected with serious mathematical difficulties, but for an approximate evaluation of the effect of the radial field it is possible to solve the problem for certain simplifying assumptions. Assuming the emitter current density to be independent of the distance r from the center of the emitter, the approximate law of potential difference u distribution can be stated as:

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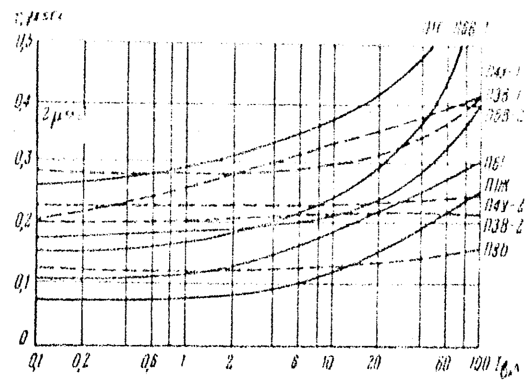
Fig. 7. Experimental curves $\tau = f(I_b)$. For the dotted curves scale to the right equals 2 μsec.



sawtooth-type pulses. Experiments proved the parabolic shape of $I_k = f(I_b)$. Coefficients a and b of (3) were determined from two points of the curve $I_k = f(I_b)$, drawn theoretically and compared with experimental results. For type П6 triodes the theoretical and experimental curves differed by 3-5% in the interval of I_b = 0-10 ma, and 10-350 ma. Based on the measurements of the time constant of the transient small signal characteristic, the values of τ were determined. Results are plotted in Fig. 7. It follows from formulas (9) and (4) that $\tau = \tau_{1e}/\beta_{\Delta}$. In accordance with the above results about the mechanics of the processes in the triode, this relation must be constant. The curves show this to be true for a comparatively wide range, with exception of triodes П1 and П6, which show a two- or threefold increase of τ for an increase of I_b from 0.1 to 100 ma. Analysis of the leading and trailing edge for a rectangular-shaped pulse on type rigid coupling between the input and output currents of the triode $I_{in} = f(I_k)$. From (1) and (5) for these conditions:

$$\xi = \int \frac{dx}{\varphi(x) - (b + x)x} \quad (17)$$

from which conditions of self-excitation for the investigated circuits follow:

$$\varphi(x) > (b + x)x. \quad (18)$$

The most often encountered case is $I_{out} = n\, I_k$ or $\varphi(x) = nx$. The self-excitation condition is $n > b + x$.

2. Experimental Part. The above analysis did show that the most pronounced dependence of the triode characteristics on the signal level appears in circuits with common emitter; therefore, the experiments were conducted with this arrangement. All measurements, including static characteristics $I_k = f(I_b)$, were made by the pulse method, the variable being given by long

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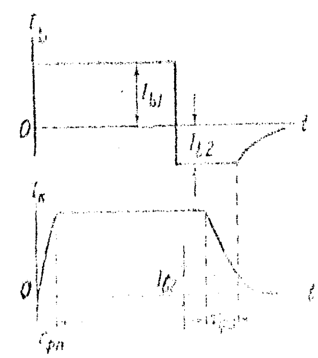

Fig. 5. Collector current pulse form for a given base current pulse form.

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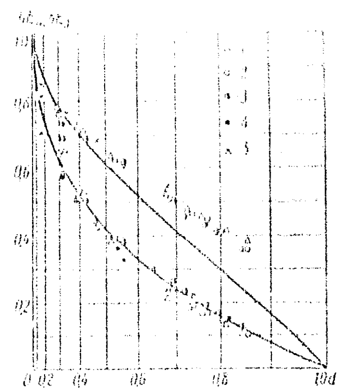

Fig. 4. Duration of leading and trailing edges in a circuit with common emitter vs. level of input signal ($d = x_k/(x_k + b)$ or $d = x_s/(x_s + b)$); dots show experimental results with several triodes: (1) П6А; (2) П6В-1; (3) П6В-2; (4) П3В; (5) П4Г.

durations when the collector current is saturated, for circuit with common base, are calculated per (13) and (14), but for common emitter--per (11). 3. In some relaxation systems, e.g., with transformer feedbacks, the regeneration processes proceed in presence of a

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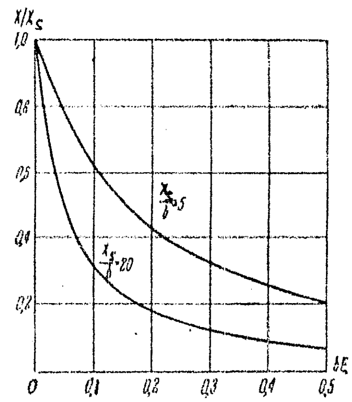

Fig. 2. Trailing edge curves for a circuit with common emitter.

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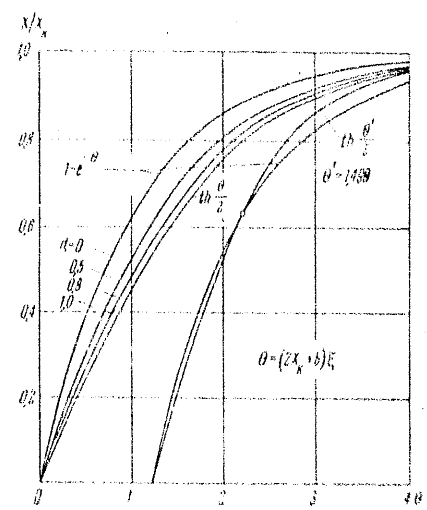

Fig. 1. Front edge curves $x/x_k = f(\theta)$ for a circuit with common emitter. Boundary curves are shown separately, so that they coincide at the 0.63 level.

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$$x/x_s = \exp(-\xi/\alpha_0). \qquad (13)$$

The front edge for $x_k \ll 1$ is described by an exponential:

$$x/x_k = 1 - \exp\left[-\left(2x_k + \frac{1}{\alpha_0}\right)\xi\right]. \qquad (14)$$

These are only approximations, however. In the circuit with common emitter the front and trailing edge curves are different from the exponential. Figure 1 shows the front edge curves for different values of $d = x_k/(x_k + b)$. The exponential and calculated curve for $d = 1$ are also shown for comparison. The leading edge curves differ only slightly from the exponentials; therefore, the front duration can be characterized by the respective time constant. The trailing edge curves differ considerably from the exponentials. Curves of time constants are shown on Fig. 4. C. Leading and trailing edge

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The ratio of time constants for a circuit with common emitter and circuit with common base is:

$$\tau_{1e}/\tau_{1b} = 1 + \beta_{\Delta}. \tag{10}$$

This formula agrees with the results of more exact developments. B. From (7) expressions are derived for the leading and trailing edge of the output pulse, taking into consideration that for the leading edge $x_s = 0$ but for the trailing edge $x_k = 0$, respectively:

$$\frac{x}{x_K} = \frac{1 - e^{-(2x_K+b)\xi}}{1 + \frac{x_K}{x_K + b} e^{-(2x_K+b)\xi}}, \tag{11}$$

$$\frac{x}{x_S} = \frac{e^{-b\xi}}{1 + \frac{x_S}{b}(1 - e^{-b\xi})}. \tag{12}$$

For a circuit with common base for the trailing edge with $x_s \ll 1$:

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These solutions are analyzed for three cases: (A) small jump on the background of a great constant component; (B) transmission of a rectangular pulse of the input current when the starting current is zero; (C) front and trailing edge in presence of saturation collector current. A. Equation (7) shows that with decrease of the jump $(x_k - x_s)$ the denominator tends to unity. If the magnitude of the jump satisfies the condition:

$|x_k - x_s| \ll b$, the transient function for x is an exponential:

$$\frac{x_K - x}{x_K - x_s} = e^{-(2x_K+b)\xi}, \tag{8}$$

the time constant of which τ_1 is decreasing with increase of the constant component:

$$\tau_1 = \frac{\tau}{2x + b}, \quad x_K \simeq x. \tag{9}$$

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$$\xi = \frac{1}{\sqrt{b^2 + 4c}} \ln \frac{(2x_s + b - \sqrt{b^2 + 4c})(2x + b + \sqrt{b^2 + 4c})}{(2x_s + b + \sqrt{b^2 + 4c})(2x + b - \sqrt{b^2 + 4c})} \qquad (6)$$

or solving it for x, and considering that the final value of x_k is $1/2\,(\sqrt{b^2 + 4c} - b)$:

$$\frac{x_k - x}{x_k - x_s} = \frac{e^{-(2x_k + b)\xi}}{1 + \frac{x_s - x_k}{2x_k + b}\left[1 - e^{-(2x_k + b)\xi}\right]}. \qquad (7)$$

For $c < 0$ when $b^2 + 4c < 0$, which is usually the case when the triode is blocked by the base reverse current, the solution is:

$$\xi = \frac{2}{\sqrt{-(b^2 + 4c)}}\left[\operatorname{arc\,tg} \frac{2x_s + b}{\sqrt{-(b^2 + 4c)}} - \operatorname{arc\,tg} \frac{2x + b}{\sqrt{-(b^2 + 4c)}}\right]. \qquad (7')$$

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where $k(k_{\Delta})$ has the meaning of $\alpha(\alpha_{\Delta})$ or $\beta(\beta_{\Delta})$ dependent upon whether the triode is connected to a circuit with a common base or a common emitter. α and β decrease with an increase of the collector current, especially β. 2. The process of establishing the triode collector current at the sudden change of input current is described by Eq. (1), which, by substitution of variables, can be reduced to a form containing the minimum number of constants:

$$x' + (b + x)x = c. \qquad (5)$$

Here $x = \alpha I_k$, $\xi = t/\tau$, $x' = dx/d\xi$ and $c = \alpha I_{in}$, where I_{in} corresponds to the input current magnitude after the jump. Solution of this equation with consideration of the initial value of $x(0) = x_s$ and for $b^2 + 4c > 0$ is:

the shape of a parabola:

$$I_{in} = (b + aI_k)\, I_k, \qquad (3)$$

For $I_{in} = I_b$ the addendum bI_k (equal I_k/β_o) is the surface and volume recombination current, and also the electron current of the emitter due to the equilibrated concentration of electrons in the base. The addendum aI_k^2 corresponds to the electron current through the emitter junction, due to the surplus electron concentration in the base. Limitations imposed on Eq. (1) and experiments proved the validity of the above for $aI_k < 0.2$-0.3. The amplification coefficients for the differential k_Δ and constant current k are:

$$k_\Delta = \frac{\Delta I_k}{\Delta I_{in}} = \frac{1}{2aI_k + b}, \qquad k = \frac{I_k}{I_{in}} = \frac{1}{aI_k + b}, \qquad (4)$$

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was based on the following regularities and assumptions: (1) The character of hole concentration distribution in the base does not depend on the intensity of signal (principle of similarity). (2) The effective diffusion coefficient, volume, lifetime, and speed of surface recombination are constant. (3) The electron component of the emitter current is proportional to electron concentration in the base at the emitter junction. There are no limitations imposed on the geometry of the plane triodes. The equation cannot be solved in general form, therefore the more interesting particular cases, for which solutions are possible, are analysed: (1) static characteristic $I_k = f(I_{in})$; (2) process of establishing the collector current for a sudden change of input current, $I_k = \varphi(t)$ for I_{in} = const; (3) transient processes in the triode, operating in a circuit with positive rigid feedback, that is, $I_{in} = f(I_k)$. 1. The static relation between input and output currents has

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$$I_{in} = \begin{cases} I_e - \text{emitter current} \\ I_b - \text{base current} \end{cases}, \quad \frac{1}{b} = \begin{cases} \alpha_0 \\ \beta_0 \end{cases}, \qquad (2)$$

a is coefficient of proportionality between the electron current of the emitter I_e, connected with the surplus charge Q in the holes of the base, and I_k^2; $\alpha_0 = I_k/I_e$ and $\beta_0 = I_k/I_b$ for $I_k \rightarrow 0$. On the other hand, $\beta_0 = \tau_n/\tau$ where $\tau_n = Q/I_b$ for $I_k \rightarrow 0$, and I_b in this case is equal to the sum of currents of surface and volume recombination, and of the electron current of the emitter, which is determined by the equilibrium concentration of electrons in the base; τ_n is effective life of holes in the base; $\tau = Q/I_k$, proportionality coefficient between the excess charge and the collector current. The development of Eq. (1)

characteristics is used. It should provide an explanation of such experimental facts as the relation of the duration of the transient process to the level of the input signal, difference of risetime of the leading edge of an output pulse from the trailing edge while transmitting a large rectangular-shaped input current pulse, etc. To solve this problem, Eqs. (9) and (10), derived in a previous work, will be used (Abdyukhanov, M. A., Berestovskiy, G. N., Kuz'min, V. A., "On the Calculation of Processes in Transistor Triodes by the Charge Method," this Journal, 5,3,450 (1960)). These equations are written as one:

$$\tau \frac{dI_{\text{к}}}{dt} + (b + aI_{\text{к}}) I_{\text{к}} = I_{in}, \tag{1}$$

where, depending on the scheme of connection of the triode, values I_{in} and b shall designate:

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AUTHOR: Berestovskiy, G. N.

TITLE: Static Characteristics and Transient Processes in a Transistor Triode at Large Signals

PERIODICAL: Radiotekhnika i Elektronika, 1960, Vol 5, Nr 3, pp 460-470 (USSR)

ABSTRACT: 1. Theory. Investigations of several authors proved that the relation between the input current of the triode and the collector current is nonlinear, determined mainly by the nonlinear relation of the electron component of the emitter current to the collector current. This nonlinearity somehow reflects also on the transient processes in the triode, and therefore it seems to be important to investigate these relations more closely. Such analysis should provide the possibility of properly evaluating the error which results when for large signals the linear interpretation of the transistor triode

On the Calculation of Processes in Transistor Triodes by the Charge Method

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SOV/109-5-3-13/26

Materials, RCA Rev., 17, 1, 37 (1956); N. H. Fisher, Self-Bias Cutoff Effect in Power Transistors, Proc. I.R.E., 43, 11, 1669 (1955)

ASSOCIATION: School of Physics, Moscow. Government University imeni M. V. Lomonosov, Chair of Oscillation Theory (Fizicheskiy Fakul'tet Moskovskogo Gosudarstvennogo Universiteta im. M. V. Lomonosova, Kafedra Teoriyi Kolebaniy)

SUBMITTED: May 12, 1959

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On the Calculation of Processes in Transistor Triodes by the Charge Method

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Conclusions. The charge method being convenient for engineering calculations of problems of transistor triode electronics is as valid for slow processes as the known methods based on solution of continuity equations. For many instances it is valid also for processes with time constants close to the critical frequency. It is possible that this method, after some modifications, could be applied to calculations of problems not only of fused, but also of drift transistor triodes. There are 4 figures; and 21 references, 8 Soviet, 11 U.S., 2 Japanese. The most recent or referred to U.S. references are: W. Shockley, M. Sparkes, G. Teal, P-N Transistor, Phys. Rev., 83, 7, 151 (1951); J. Sparkes, R. Beufoy, The Junction Transistor as a Charge Controlled Device, Proc. I.R.E., 45, 12, 1740 (1957); F. G. Hyde, Some Measurements of Commercial Transistors and Their Relation to Theory, Proc. I.R.E., p. B. 105, 19, 45 (1958); L. D. Armstrong, C. L. Carlson, M. Bentivedna, P-N-P Transistor Using High-Emitter-Efficiency Alloy

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voltage on the collector is caused by a load at the output $v_{ko} = -i_{ko} R_l$, it follows from (23) that:

$$i_{\kappa 0} = \frac{a}{1 + R_l G_\kappa}. \qquad (29)$$

which shows that with increase of the load resistance the amplification coefficient per current drops. Figure 4 shows comprehensively the change of collector voltage with thickness of base.

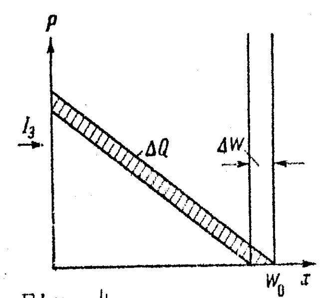

Fig. 4.

Fig. 4. Dependence of the charge Q on the thickness of the base zone W at constant emitter current.

model of the triode:

$$g_{н} = \frac{g_0 + \omega^2 \tau_D C_0}{1 + \omega^2 \tau_D^2}, \quad C_{gк} \simeq \frac{C_0}{1 + \omega^2 \tau_D^2}, \tag{26}$$

where g_0 and C_0 are values of the active part of the output conductance and diffusion capacity at low frequencies, determined by:

$$g_0 = \frac{\partial(\eta_0 \gamma_0)}{\partial W} \frac{\partial W}{\partial V_{н}} I_{э0}, \tag{27}$$

$$C_0 = -\gamma_0 \frac{W_0}{D_p} \frac{\partial W}{\partial V_{н}} I_{э0}, \tag{28}$$

which coincide with the exact expressions derived from solution of the diffusion equation by J. M. Early (U.S. ref). The expressions for output conductivity are valid up to the critical frequency. If the variable

$$i_{\kappa 0} = \alpha i_{\textit{э}0} + G_{\kappa} v_{\kappa 0}. \tag{23}$$

where

$$\alpha = \frac{\gamma_0}{1 + \frac{\tau_\kappa}{\tau_p} + j\omega\tau_\kappa} \approx \frac{\alpha_0}{1 + j\omega\tau_D} \tag{24}$$

is the amplification coefficient per current for shortcircuited output given as approximation valid up to the critical frequency and

$$G_\kappa = \frac{\gamma_0}{1 + j\omega\tau_D}\left[-\frac{1}{\tau_p}\frac{\partial\tau_\kappa}{\partial W} I_{\kappa 0} + \frac{\partial\gamma}{\partial W} I_{\textit{э}0} - j\omega\frac{\partial\tau_\kappa}{\partial W} I_{\kappa 0}\right]\frac{\partial W}{\partial V_\kappa} \tag{25}$$

the output conductance, dependent on the modulation of the thickness of the base zone. Separating the active and reactive part of G_k for the one-dimensional

On the Calculation of Processes in Transistor Triodes by the Charge Method

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$$\frac{dQ}{dt} = -\frac{Q}{\tau_p} + I_{\text{э}} - I_{\text{к}} \qquad (20)$$

will be solved. For emitter current:

$$I_{\text{э}} = I_{\text{э}0} + i_{\text{э}0} \exp j\omega t,$$

for collector current:

$$I_{\text{к}} = I_{\text{к}0} + i_{\text{к}0} \exp j\omega t$$

for collector voltage:

$$V_{\text{к}} = E_{\text{к}} + v_{\text{к}0} \exp j\omega t,$$

where i_{ko} and v_{ko} are complex amplitudes. After respective substitutions the complex amplitude is calculated from (20) as:

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$$\frac{1}{\tau_p}+\frac{(\arccos\gamma)^2}{2\tau_D}\simeq\frac{1}{\tau_p}+\frac{1-\gamma}{\tau_D},$$

which is close to the one given in Eq. (17). 3. Calculation of the current amplification coefficient and output conductance of the transistor triode with consideration of the modulation of the base zone thickness. A harmonically varying current with an amplitude small as compared with the amplitude of the emitter bias current, is applied at the input of the transistor triode with a grounded base. Limiting calculations to low injection levels, the modulation of the base thickness is considered. All variables depending on time are assumed to vary harmonically, and to be small in magnitude as compared with variables corresponding to a steady state. The equation of conservation of charge:

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$$I_K(t) = \frac{\alpha}{1-\alpha} I_{b0}\left\{1 - \exp\left[-\frac{(1-\alpha)t}{\gamma\tau_D}\right]\right\} \qquad (18)$$

(the authors refer here to J. Sparkes, R. Neaufoy, U.S. ref). From these expressions it follows that the collector current varies with the time constant $\tau^* < \tau_p, \tau_D$. The influence of the electron current on the where the inequality increases with decrease of γ and transient characteristic can be ignored when $\tau_e/\tau_p \geq 10$ or:

$$\frac{\gamma(1-\eta)}{1-\gamma} \geq 10. \qquad (19)$$

Usually $\eta = 0.98$ and (19) is satisfied when $\gamma \geq 0.998$. For values γ close to one the index of the exponential of formula (12) is:

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τ_e can be determined:

$$\tau_e = \frac{\gamma\tau_D}{1-\gamma}. \qquad (15)$$

The solution of (13) is:

$$I_K(t) = \frac{\eta\tau^*}{\tau_D} I_{bo}[1 - \exp(-t/\tau^*)]. \qquad (16)$$

Taking (15) into consideration and using the equation $\tau_D = \tau_p(1-\eta)$, we get:

$$I_K(t) = \frac{\alpha}{1-\alpha} I_{bo}\left\{1 - \exp\left[-\left(\frac{1}{\tau_p} + \frac{1-\gamma}{\gamma\tau_D}\right)t\right]\right\} \qquad (17)$$

or

$$h_a(t) = \frac{2\arccos\gamma}{\sqrt{1-\gamma^2}} \cdot \frac{1 - \exp\left\{-\left[\frac{1}{\tau_p} + \frac{(\arccos\gamma)^2}{2\tau_D}\right]t\right\}}{\frac{\tau_D}{\tau_p} + \frac{(\arccos\gamma)^2}{2}}. \qquad (12)$$

The transient characteristic for the transistor-triode is now calculated for moment $t = 0$ at which the base current jumps from 0 to I_{bo}. For a small signal in (7), the second term can be ignored, and Eq. (9) can be written as:

$$\frac{dI_k}{dt} + \frac{I_k}{\tau^*} = \frac{I_{bo}}{\tau_\beta}, \qquad (13)$$

where

$$\frac{1}{\tau^*} = \frac{1}{\tau_p} + \frac{1}{\tau_r}, \quad t_\alpha = \frac{1}{a_1}. \qquad (14)$$

From the steady distribution of holes in the base,

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of the emitter are important only for circuits where the charge at the base varies with the time constant, considerably exceeding τ_D; hence Eqs. (5) and (7) can be considered valid. Equation (1) expressing the law of charge conservation is valid for any geometry of the base. But since Eqs. (1)-(5) were proved only by solution of the continuity equation for a one-dimensional case, the field of application of the method is proved only for a one-dimensional model of transistor-triodes.

2. On the Influence of the emitter electron current on the transient characteristic of the transit triode, connected with a common emitter. The influence of the injection coefficient on the transient characteristic of the triode was investigated by E. I. Adirovich and K. V. Temko (USSR). In this work within the frame of theory of a small signal and assuming γ = const during the transient process, the diffusion equation for holes of the base was solved, but giving a cumbersome result, approximated by the following equation:

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Fig. 2. Transient characteristics of transistor triode in a circuit with a common base: (I) exact curve; (II) calculated per (11).

Fig. 3. Hole concentration in the emitter base at different times: (p_1, p_2, p_3) actual values: (p_1', p_2', p_3') calculated per (4).

This investigated example proves that for many practical cases relation (3) is valid and sufficiently accurate; the same is true when the base charge varies with the time constant $\tau \simeq \tau_D$. Figure 3 shows the distribution of holes in the base at different moments; since the calculated values (per 4) are lower than the actual, the I_{SR} and I_{ne} are also smaller than the actual magnitudes. But the influence of the recombination current and electron current

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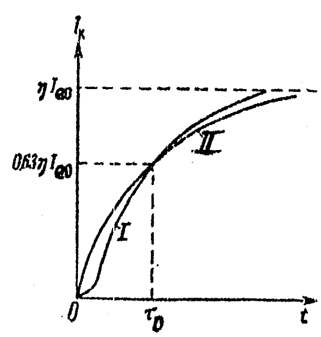
Its solution is:

$$I_к(t) = \eta I_{э0}[1 - \exp(-t/\tau_D)], \tag{11}$$

which is very often used for practical applications. Figure 2 shows the exact transient characteristic I and the approximated II as calculated per (11), where a pronounced difference may be seen at $t < 0.2\,\tau_D$.



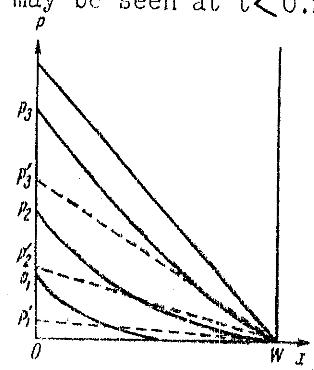


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Fig. 2 Fig. 3

See caption to both figures on Card 10/21

$$\tau_{\text{K}} \frac{dI_{\text{K}}}{dt} + \left(1 + \frac{\tau_{\text{K}}}{\tau_{\text{p}}} + a_1 \tau_{\text{K}}\right) I_{\text{K}} + a_2 \tau_{\text{K}}^2 I_{\text{K}}^2 = I_{\text{C}}. \tag{10}$$

These conditions are valid as long as charge Q varies with sufficient slowness in comparison to the diffusion time τ_D. If the charge varies with the time constant $\tau \simeq \tau_D$, the charge method can give considerable error. In some cases, however, the method can still be used as an approximation for some fast processes. As an example, the transient characteristic of a triode with a common base for small signals is investigated. The emitter current suddenly changes from 0 to I_{eo} at some $t = 0$. $I_k(t)$ is sought. For simplicity the emitter current I_{ne} is ignored. Eq. (10) takes shape:

$$\tau_D \frac{dI_{\text{K}}}{dt} + I_{\text{K}} = \eta I_{e0}.$$

$$I_{\text{нэ}} = a_1 Q + a_2 Q^2, \tag{7}$$

where a_1 and a_2 are constant coefficients. Substituting the above expressions for (1), and taking into consideration that $I_{pe} = I_e - I_{ne}$; $I_{pk} = I_k$, $I_b = I_e - I_k$, the equations, which together with conditions (1) and (5) constitute the whole set needed for calculations per charge method, are derived:

$$\frac{dQ}{dt} + \frac{Q}{\tau_p} + a_1 Q + a_2 Q^2 = I_b \tag{8}$$

or

$$\tau_{\text{н}} \frac{dI_{\text{н}}}{dt} + \left(\frac{\tau_{\text{н}}}{\tau_p} + a_1 \tau_{\text{н}}\right) I_{\text{н}} + a_2 \tau_{\text{н}}^2 I_{\text{н}}^2 = I_b. \tag{9}$$

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effective lifetime τ_p, the equation is written:

$$I_R = I_{VR} + I_{SR} = Q / \tau_p, \qquad (5)$$

where

$$\frac{1}{\tau_p} = \frac{1}{\tau_S} + \frac{1}{\tau_V},$$

5. The emitter electron current can be expressed through Q, using first the equation:

$$I_{ne} = \frac{qD_n S}{L_n} n_e(0) \text{ or } I_{ne} = \frac{qD_n S}{L_n} \frac{n_b(0)\, p_b(0)}{p_e(0)}. \qquad (6)$$

Since $p_e(0) = p_p$ is equilibrium concentration of holes in the emitter, $n_b(0) = n_n - p_n + p_b(0)$ as corresponding to the neutrality condition in each point of the base and $p_b(0) = kQ$, Eq. (6) takes shape:

3. The surface recombination current I_{SR} is proportional to the hole concentration at the emitter junction:

$$I_{SR} = qsA_S p_b(0),$$

where s is surface recombination speed; A_S, effective surface area where recombination occurs. Based on (4):

$$I_{SR} = Q / \tau_S.$$

It is further assumed that s A_S = const, and also τ_S = const. 4. The volume recombination in the base zone plays a lesser role. The lifetime of holes in volume τ_V is const for low and high injection levels, but depends on the concentration for medium injection levels. For practical purposes the lifetime in volume τ_V = const for all levels. Combining the surface and volume recombination currents, and introducing the

$$I_K = \frac{\eta q D_p p_b(0) S}{W} = \eta Q \frac{2D_p}{W^2},$$

where $\eta = 1 - W^2/2L_p^2$ is transfer coefficient. Therefore,

$$\tau_K = \tau_D / \eta. \qquad (3')$$

2. Concentration of holes in the base at the emitter junction is proportional to the charge Q:

$$p_b(0) = kQ. \qquad (4)$$

This equation enables the determination of the relation between the charge on one side and the current of surface recombination and electron current of the emitter on the other.

$$k = \frac{2}{qSW}.$$

ignored in comparison with the excess charge. Equation (1) can be derived also by integrating the continuity equation:

$$\frac{\partial p}{\partial t} = -\frac{p - p_n}{\tau_p} - \frac{\operatorname{div} I_p}{q} \qquad (2)$$

over the whole volume V of base. In order to apply (1) to practical calculations, additional conditions relating the triode (working as an amplifier) currents to the charge Q are needed. 1. Relation of collector current to charge is given by:

$$I_k = Q / \tau_k, \qquad (3)$$

where τ_k is coefficient depending on physical properties of the base zone of the triode. The distribution of holes in the base is linear and τ_k = const. For low injection rates:

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relations between currents in the triode and the surplus charge carriers in the base, and analyzes the limits of the application of the charge method. Calculation examples help to evaluate its simplicity. 1. Basic relationships. The equation formulating the law of conservation of the full charge of holes in the base (p-n-p-triode) is:

$$\frac{dQ}{dt} = I_{pe} - I_{pk} - I_{VR} - I_{SR}. \qquad (1)$$

where

$$Q = q \int_V (p - p_n)\, dV$$

is the hole charge in base of arbitrary volume V, exceeding the equilibrium charge; I_{pe} and I_{pk} are hole currents of emitter and collector, respectively; I_{VR}, I_{SR} are currents of volume and surface recombination. Further, the equilibrium hole charge will be

9.4310

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SOV/109-5-3-13/26

AUTHORS: Abdyukhanov, M. A., Berestovskiy, G. N., Kuz'min, V. A.

TITLE: On the Calculation of Processes in Transistor Triodes by the Charge Method

PERIODICAL: Radiotekhnika i elektronika, 1960, Vol 5, Nr 3, pp 450-459 (USSR)

ABSTRACT: Introduction. The usual method of calculating the electrical characteristics of semiconductor triodes is the solution of the continuity problem for the minority carriers in the emitter, base, and collector zones at certain boundary conditions, which depend on applied external voltages and currents (see W. Shokley, M. Sparkes, G. Teal, U.S. ref). Although this is the most universal method, it often leads to complicated calculations. A later method (J. Sparkes, R. Beaufoy, U.S. ref) considers the semiconductor triode as a system controlled by the charge of surplus minority carriers of the base zone. The present paper investigates the

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BENDRIKOV, G.A.; KRASNUSHKIN, P.Ye.; REYKHRUDEL', E.M.; POTEMKIN, V.V.; MUSTEL', Ye.R.; RZHEVKIN, K.S.; IVANOV, I.V.; KHARLAMOV, A.A.; TIKHONOV, Yu.V.; STRELKOVA, L.P.; KAPTSOV, L.N.; ORDANOVICH, A.Ye.; KHOKHLOV, R.V.; VORONIN, E.S.; BERESTOVSKIY, G.N.; KRASNO-PEVTSEV, Yu.V.; MINAKOVA, I.I.; YASTREBTSEVA, T.N.; SEMENOV, A.A.; VINOGRADOVA, M.B.; KARPEYEV, G.A.; DRACHEV, L.A.; TROFIMOVA, N.B.; SIZOV, V.P.; RZHEVKIN, S.N.; VELIZHANINA, K.A.; NESTEROV, V.S.; SPIVAK, G.V., red.; NOSYREVA, I.A., red.; GEORGIYEVA, G.I., tekhn. red.

[Special physics practicum] Spetsial'nyi fizicheskii praktikum. Moskva, Izd-vo Mosk.univ. Vol.1. [Radio physics and electronics] Radiofizika i elektronika. Sost. pod red. G.V.Spivaka. 1960. 600 p.

(MIRA 13:6)

1. Professorsko-prepodavatel'skiy kollektiv fizicheskogo fakul'teta Moskovskogo universiteta im. M.V.Lomonosova (for all except Spivak, Nosyreva, Georgiyeva).

(Radio) (Electronics)

AUTHOR: Berestovskiy, G.N. SOV/120-59-5-40/46

TITLE: Recording Transistor Characteristics in the Saturation Region

PERIODICAL: Pribory i tekhnika eksperimenta, 1959, Nr 5, pp 141 - 142 (USSR)

ABSTRACT: Figure 2 shows the circuit, which used 50 c.p.s. alternating current; the voltage applied to the base is used to work the X sweep and the current provides the Y deflection. The traces are photographed from the screen of the oscilloscope. Figure 1 shows some curves for power transistors. There are 2 figures.

ASSOCIATION: Fizicheskiy fakul'tet MGU (Physics Dept. of MGU)

SUBMITTED: August 31, 1958

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APPROVED FOR RELEASE: 06/23/11: CIA-RDP86-00513R000204800029-6

SOV/109-4-6-24/27

New Method of Pulse Excitation of the Oscillations in a Resonant Circuit (Letter to the Editor)

circuit, acts as a generator of non-damped oscillations. Outputs having an amplitude of 10 V and a frequency of 1 Mc/s can be obtained from the above circuit when its parameters have the following values: $E = 12$ V; $C = 200$ pF; $C_1 = 470$ pF; $L \approx 100$ μH; $R = 24$ kΩ; $R_1 = 1$ kΩ and $R_2 = 0.12$ MΩ.

SUBMITTED: January 19, 1959

Card 2/2

AUTHOR: Berestovskiy, G.N. SOV/109-4-6-24/27

TITLE: New Method of Pulse Excitation of the Oscillations in a Resonant Circuit (Letter to the Editor) (Novyy sposob udarnogo vozbuzhdeniya kolebaniy v konture) (Pis'mo v redaktsiyu)

PERIODICAL: Radiotekhnika i elektronika, 1959, Vol 4, Nr 6, pp 1061 - 1062 (USSR)

ABSTRACT: It is pointed out that the so-called ringing circuits are usually based on an inductance as an energy-storage element. It is shown, however, that the storage can be effected more conveniently by means of a capacitor since, when charged, it does not require the current flow from a source. This method of storing cannot be used in the circuits based on vacuum tubes in view of large internal resistances involved. The method can be applied, however, to the circuits based on transistor devices. A pulse-excited ringing oscillator of this type is shown in the figure on p 1061. In this, the transistor T_1 serves as a key, while the transistor T_2, together with the resonant

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SOV/120-59-1-39/50

A Relay Switch

device is mounted on an absorbing substance (expanded rubber). The input resistance of each of the cathode followers is 10 MΩ. If the input capacitance of the oscillograph is 50 pF, the bandwidth of the device is about 12 Mc/s. The oscillograph is synchronized by the external signal taken from the input of either the first or the second channel. When the switch is in operation, it is possible to observe on the screen of the oscillograph two faint curves, apart from the two bright waveforms. This is due to the transient phenomena of the switch. The second disadvantage of the switch is the difficulty in displaying the signals having a frequency of 50 c/s or less. The paper contains 2 figures.

ASSOCIATION: Fizicheskiy fakul'tet MGU (Physics Dept. of the Moscow State University)

SUBMITTED: February 6, 1958.

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SOV/120-59-1-39/50

AUTHORS: Berestovskiy, G. N., Khotinskiy, M. S.

TITLE: A Relay Switch (Releynyy kommutator)

PERIODICAL: Pribory i tekhnika eksperimenta, 1959, Nr 1, pp 139-140 (USSR)

ABSTRACT: The oscillographic measurement of two voltages can be done by means of one tube, if a change-over relay is employed to switch the input of the oscillograph from one measured voltage to another (see the circuit of Fig 1). In order to obtain a versatile measurement circuit, the relay can be connected either directly to the input terminals, or, alternatively, the input signals to the relay switch are first applied to cathode followers. If the second alternative is employed, the switch acts as a two-channel pick-up with cathode followers, and its input capacitances are of the order of 10 pF. One of the channels contains a capacitance-compensated attenuator, having attenuation ratios of 1:1, 1:10 and 1:100. The oscillographic display of the signal can be adjusted vertically by the potentiometer R_1 in the cathode circuits. The switching relay is operated by the mains voltage at 6.3 V. It is a polarized relay, type RP-4. The capacitance between the open contacts of the relay is about 7 pF and its input capacitance is about 20 pF. In order to reduce the relay bounce, the

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basic physical processes occurring in the transmission of electric signals through transistors. Material is based on the results of investigations made by the department of wave theory at the physics division of MGU, where samples of Soviet alloy-type transistors were used. No personalities are mentioned. References follow each chapter.

TABLE OF CONTENTS:

9(4) PHASE I BOOK EXPLOITATION SOV/3233

Az'yan, Yu. M., G. N. Berestovskiy, L. N. Kaptsov, K. S. Rzhevkin, and K. Ya. Senatorov

Poluprovodnikovyye triody v regenerativnykh skhemakh (Semiconductor Triodes In Regenerative Circuits) Moscow, Gosenergoizdat, 1959. 311 p. 12,000 copies printed.

Ed.: S. S. Akalunin; Tech. Ed.: G. Ye. Larionov.

PURPOSE: This book is intended for scientific workers and engineers interested in problems of transistor application, and for advanced students specializing in radio physics.

COVERAGE: The book is devoted to investigation of physical processes occurring in transistorized feedback circuits, including generators of quasi-harmonic oscillations, relaxation oscillators with transformer feedback (blocking oscillators, converters), and in relaxation oscillators with RC feedback (multivibrators, triggers). The book begins with a systematic presentation of

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BERESTOVSKIY, G. N.

10 июня

(с 18 до 22 часов)

В. М. Самойленко

Тепловые режимы полупроводниковых приборов.

В. Н. Вертоградов

Исследование и расчет температурной зависимости параметров полупроводниковых триодов дрейфового типа.

Ю. Р. Носов,
В. Н. Хазанов

Осуществление температурной стабилизации усилителя напряжения на полупроводниковых триодах различных типов.

М. А. Абдюханов

О зависимости параметров сплавных полупроводниковых триодов от тока эмиттера.

Н. П. Панаева

Шумы в полупроводниковых усилителях.

11 июня

(с 10 до 18 часов)

Г. Н. Берестовский

Статические характеристики и переходные процессы в полупроводниковом триоде при большом сигнале

Т. М. Астрафьева,
В. Н. Курильчик

Исследование особенностей работы спусковой схемы на плоскостных полупроводниковых триодах при счетном запуске в зависимости от параметров триодов.

А. Ю. Горбунов

Расчет усилительного каскада на транзисторах.

В. А. Кузьмин

О влиянии режима насыщения в полупроводниковых триодах на работу импульсных схем.

11 июня

(с 18 до 22 часов)

Ю. М. Альтман,
К. Я. Сенаторов,
С. М. Чуманов

Об объемном заряде и электрическом поле в базовой области сплавного триода.

К. С. Ржевкин

Влияние модуляции толщины базы на характеристики сплавного триода.

report submitted for the Centennial Meeting of the Scientific Technological Society of Radio Engineering and Electrical Communications im. A. S. Popov (VNORIE), Moscow, 8-12 June. 1959

G.N. BERESTOVSKIY

SUBMITTED: December 7, 1957

AUTHORS: Golubkov, P.V. and Tsimring, Sh. Ye. SOV/109-3-3-22/23

TITLE: The Second All-Union Conference on Radioelectronics of the Ministry of Higher Education of the USSR (Vtoraya vsesoyuznaya konferentsiya MVO SSSR po radioelektronike) - News Item

PERIODICAL: Radiotekhnika i Elektronika, 1958, Vol 3, Nr 3, pp 440 - 444 (USSR)

ABSTRACT: The conference took place during September 23 - 29, 1957, at Saratovskiy gosudarstvennyy universitet imeni N.G. Chernyshevskogo (Saratov State University imeni N.G. Chernyshevskiy). Apart from the universities, the conference was attended by the representatives of some scientific research institutes of the Soviet and Ukrainian Academies of Science, various industrial establishments and the interested ministries. This arrangement stimulated the discussion and evaluation of the papers presented and permitted the determination of plans for the future research to be carried out by the universities in the field of radioelectronics.

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The paper by A.A. Semenov and G.A. Karneyev entitled: "The Problems of the Statistical Evaluation of the Results of Measurements in the Investigation of the Rapid Fluctuations of Ultra-shortwave Radio Signals" aroused considerable interest; similarly, the paper by A.A. Semenov and Ch.Ts. Taydypov under the title "Investigation of the Variations of the Direct Radio Signal Propagation in the Non-uniform Troposphere over a Ground Path" was of considerable interest. The latter paper gave some results of an experimental investigation of the fading of the direct ray over a medium-distance ground path. The statistical characteristics of the amplitude fluctuation of the signal were investigated and an attempt was made to clarify the mechanism of the signal variations. During the ensuring discussion, the great practical value of the above works was emphasised and it was suggested that the work should be extended in order to attain a greater accuracy. Twelve papers and communications were read at the Semi-conductor Section. L.C. Berman gave an approximate method of calculating the transients in a transistor operating with

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large signals.

[illegible] silicone carbide (the absorbing component). The investigation showed that the samples produced had satisfactory characteristics. The development of non-linear semi-conductor resistances was described in a paper of V.V. Pasynkov and L.K. Chirkin; resistance elements for powers of 10-15W were produced and their applications were studied. A method of calculating an inverse peak current in p-n diodes was given in the paper of L.I. Baranov and M.C. Bekbulatov. The formulae obtained made it possible to explain various forms of the peaks observed in the experiments. The paper by Yu.B. Az'yan, G.N. Berestovskiy, L.N. Kaptsov, V.V. Migulin, K.S. Rzhevkin, K.Ye. Senatorov and T.N. Yastrebtseva contained a survey of the works dealing with the applications of transistors in various radio circuits. G.N. Berestovskiy read a paper in which he gave the analysis of the operation of a transistor AC-DC converter. The experimental data corroborated the accuracy of the formulae proposed by the author and showed that a high conversion efficiency could be obtained with a number of Soviet transistors. During the conference, a number of trips were arranged to various industrial establishments of the town of Saratov. During the closing plenary session of the conference, on September 28, a unanimous resolution summarising the work of the conference and containing recommendations with regard to the subject matter and the plans for the future work was adopted. It was also decided that the third All-Union conference of the Ministry of Higher Education of the USSR on radioelectrons would be held in Khar'kov in September, 1959.

BERESTOVSKIY, G. N.

G. N. Berestovskiy, "Key operating regions of semiconducting triodes in resonance power amplifiers." Scientific Session Devoted to "Radio Day", May 1958, Trudrezervizdat, Moscow, 9 Sep 58.

A computation is made of an amplifier in terms of a given frequency and output power. It is shown that violent oscillations, almost harmonic, in frequencies to 10 - 15 kc can be obtained in II3B triodes. The maximum power given off in a load with II3B triodes is about 15 w and with II4 triodes, about 60 - 80 W for a supply voltage of U = 12 V.

120-3-24/40

A Pulsed "Characterograph" for Plane (Junction) Semiconductor Triodes.

increasing sawtooth voltage ($Л_{10}$, $Л_{11}$) and the other a falling voltage ($Л_9$, $Л_{10}$). These generators are controlled by negative pulses from the multivibrator. For a stable picture, the driving blocking oscillator is synchronized from the 50 c/s mains. $Л_3$ is the bright-up valve. The sweep voltage is taken from R_9 in the collector circuit. Switch $П_1$ is used to change the triode connections and the polarity of the rectangular pulses. The cathode follower $Л_7$ in the Y amplifier circuit reduces the effects of stray capacity. Details of the transformers TU_1 and TU_2 which determine the minimum pulse duration are given. There are 3 illustrations and no references.

ASSOCIATION: Department of Physics of the Moscow State University imeni M. V. Lomonosov (Fizicheskiy fakul'tet MGU im. M.V. Lomonosova)

SUBMITTED: January 26, 1956.

AVAILABLE: Library of Congress.

Card 3/3 1. Semiconductors-Characteristics 2. Triodes-Characteristics 3. Transformers

120-5-24/40

A Pulsed "Characterograph" for Plane (Junction) Semiconductor Triodes.

to the base circuit. The duration of the pulses can be varied from 20-100 μsec. The characteristic is displayed on a CRT, the beam being deflected by a voltage proportional to the collector current. The block diagram is given in Fig.2 and the circuit in Fig.3. The rectangular and saw-tooth current pulses are obtained from corresponding voltage pulses by the power amplifiers ($Л_1$ and $Л_2$) in the cathodes of which are connected the primary windings of TU_1 and TU_2. The secondary windings are connected through variable resistors to the semi-conductor electrodes. The transformers are necessary to permit change of the polarity of the pulses to the input circuits of the semi-conductor triodes when the circuit connections (common base or common emitter) are changed by switch $П_1$. Smooth change of the pulses from zero to maximum amplitude is obtained by varying the bias applied to the grids of the amplifiers. The positive rectangular pulses are produced by a triggered vibrator ($Л_6$). The positive sawtooth pulses are produced by two generators: one generator giving an

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BERESTOVSKIY, G.N.

120-3-24/40

AUTHORS: Senatorov, K.Ya. and Berestovskiy, G.N.

TITLE: A Pulsed "Characterograph" for Plane (Junction) Semi-conductor Triodes (Impul'snyy kharakteriograf dlya ploskostnykh poluprovodnikovykh triodov)

PERIODICAL: Pribory i Tekhnika Eksperimenta, 1957, Nr 3, pp.84-87 and 2 plates (USSR)

ABSTRACT: To apply theoretical calculations to pulsed circuits, using semi-conductor triodes, it is necessary to obtain the volt-amp characteristic curves under conditions approximating to the working regime of the circuit. The deciding factor which determines the choice of the families of curves is the stability of the value of the parameter with change of the independent variable. Experiment shows that the families most easily obtained are $U_k = f_1(i_k, i_\sigma = \text{const})$, and $U_\sigma = f_2(i_k, i_\sigma = \text{const})$. (U - voltage, i - current, k - collector, σ - base). Fig.1 shows such curves taken with the described characterograph. The collector current in the characterograph is a falling or growing sawtooth. A rectangular current pulse is applied

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109-9-11/15

A Voltage Converter Employing High Power Transistors.

converter may not oscillate if it feeds into a rectifier with a capacitive input filter. It is therefore necessary to use an input inductance followed by a capacitance. There are 10 figures, 3 of which are sets of oscillograms, and 5 references, of which 3 are Slavic.

ASSOCIATION: Physics Faculty of the Moscow State University im. M.V. Lomonosov (Fizicheskiy Fakul'tet Moskovskogo Gosudarstvennogo Universiteta im. M.V.Lomonosova).

SUBMITTED: February 25, 1957.

AVAILABLE: Library of Congress.

Card 5/5

109-9-11/15

A Voltage Converter Employing High Power Transistors.

equation for the collector current is found (see Eq.(13)). From the above it is found that the rise time of the change-over measured over voltages from 0.2 E to -E is given by:

$$\tau_{\Phi} = \frac{2.3\tau}{n\alpha_{э}}\left(1 + \frac{r_{вхп}}{R_{H}}\right) , \quad (16)$$

where $r_{вхп}$ is the input resistance of the transistor and τ is the fall time determined experimentally for a given transistor (τ is of the order of 40 μs). It is also shown that the oscillation (or self-excitation) condition for the system is given by:

$$R_{H} > \frac{nr_{вх}}{\alpha_{э}}$$

, from which it follows that the system cannot start oscillating if it is fully loaded. It is possible, however, to initiate the oscillation by inserting a capacitor of about 0.3 μF between the collector and the base of one of the transistors. It is also found that the

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A Voltage Converter Employing High Power Transistors.

$$P_H = \frac{n^2 E^2}{(n+1)^2 R_H}, \quad (11)$$

where R_H is the load and n is the turns ratio of the collector and the base windings of the transformer. Output power, power losses and efficiency of the converter as a function of n are plotted in Fig.6. It is found that efficiencies as high as 90% are comparatively easily attainable. At the end of the slow process one of the transistors "enters" into the so-called active region (to the left of N - N line in Figs.3) and the system undergoes a change-over into the second state. For the analysis of the change-over it is assumed that the current amplification coefficient of a transistor $\alpha_э$ is constant and that the input impedance of the transistor is also a constant quantity. It is further assumed that the inertia effects in the transistors are of importance during this stage while the transformer magnetising current does not change and the transistor which is being opened has a negligible effect. An equivalent circuit of the system for the change-over is derived (see Fig.7) and the transient

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state. Duration of the slow process is primarily determined by the inductance of the transformer and by the type of the transistor characteristics in the saturation region. For the analysis of the system it is assumed that its $u_k = f(i_б)$ at i_k = const and $u_б = f(i_б)$ at i_k = const can be approximated by broken straight lines (see Figs.3), where u_k, i_k, $u_б$ and $i_б$ are the collector and the base voltages and currents respectively. The equivalent circuit of the system for the slow processes is derived (see Fig.4) and it is shown that the duration of the pulses is given by: $T \approx \frac{2L j_N}{E}$, (9)

where L_N is the equivalent inductance of the transformer, E is the supply voltage and j_N is the limiting value of the magnetising current (determined by a point on the line N - N in Figs.3). It is also shown that the output power of the system is given by:

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BERESTOVSKIY, G.N.

109-9-11/15

AUTHORS: Berestovskiy, G.N. and Senatorov, K.Ya.

TITLE: A Voltage Converter Employing High Power Transistors (Preobrazovatel' napryazheniya na moshchnykh poluprovodnikovykh triodakh)

PERIODICAL: Radiotekhnika i Elektronika, 1957, Vol.II, Nr 9, pp.1178 - 1188 (USSR)

ABSTRACT: The converter employs two Soviet power transistors, type П3B, which are connected in a push-pull oscillator circuit (see Fig.2). The system consists of a triple transformer in which the supply source is connected to the collectors of the transistors and the base voltages are provided by two special identical windings; the load is connected across a secondary winding. During the operation of the converter the transistors are being successively opened or closed. While one of the transistors is being cut off, the voltage at the base of the second transistor changes its polarity and thus the transistor becomes conducting. The changeover process is comparatively rapid. After the changeover the currents in the system change comparatively slowly since the magnetising current in the transformer, j , increases rather slowly. At a certain value of j the increase in the current ceases and the system changes over to the second

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AID P - 4542

Radiotekhnika, 3, 34-40, Mr 1956

Card 2/2 Pub. 90 - 5/9

initial phase. Twelve diagrams and oscillograms, 2 Soviet references (1952, 1954).

Institution : None

Submitted : Ja 29, 1955

APPROVED FOR RELEASE: 06/23/11: CIA-RDP86-00513R000204800029-6

BERESTOVSKIY, G.N.

AID P - 4542

Subject : USSR/Electronics

Card 1/2 Pub. 90 - 5/9

Authors : Voronin, E. S. and G. N. Berestovskiy

Title : Synchronization of a self-oscillator with radio-frequency impulses.

Periodical : Radiotekhnika, Vol. 11, 3, 34-40, Mr 1956

Abstract : The authors investigated the problem of establishing conditions for the synchronization of self-oscillating systems subjected to the action of radio-frequency impulses which have a carrier frequency close to the frequency of harmonic self-induced oscillations. The authors studied the problem analytically and established the phase and amplitude of the self-oscillations. They then checked the results experimentally for a frequency of 1Mc and found that these corresponded closely with the theoretical ones. They conclude the article by stating that the time of synchronization depends in a high measure on the

USSR / Radiophysics. Application of Semiconductors. I-8

Abs Jour : Ref Zhur - Fizika, No 5, 1957, No 12600

: usable flat pulses it is necessary to increase the transformation coefficient and to introduce into the collector circuit an additional resistance or inductance. During the process of formation of the trailing front, the important role is played by the external parameters of the circuit and by the capacitor of the collector junction of the transistor. On the basis of the approximate equivalent circuit, an expression is derived for the trailing front of the collector voltage.

The calculated data are confirmed experimentally.

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USSR / Radiophysics. Application of Semiconductors

Abs Jour : Ref Zhur - Fizika, No 5, 1957, No 12600 I-8

: delay of the transistor. This is why calculation of the leading front is first carried out with allowance for only this time delay, followed by successive approximations of the influence of the leakage inductance of the transformer, of the capacitance of the blocking generator, of the capacitance of the collector junction, and of other circuit parameters on the time of front formation. In view of the fact that the linearization of the transistor characteristics leads to substantial errors in the calculation of the peak of the pulse, analysis with the aid of quasi-stationary characteristics and the plotting of the dynamic characteristic is employed for this stage. The analysis shows that, in the case of a transformation coefficient n = 1, pulses with flat peaks are possible only at small supply voltages (1 - 2 volts). To obtain practically

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USSR /Radiophysics. Application of Semiconductors I-8

Abs Jour : Ref Zhur - Fizika, No 5, 1957, No 12600

: the peak of the pulse is formed, the method of piecewise-linear approximation of the transistor characteristic. At the boundaries of the stages, the solutions of the differential equations are joined together. On the basis of the analysis of the equivalent circuit for the capacitor-charging stage, an analytic expression is obtained for the duration of the pause between the pulses in terms of the circuit parameters and in terms of the averaged transistor parameters.

In view of the fact that at this stage the equivalent circuit changes substantially in a grounded-base transistor connection, this case is examined separately. It is shown that, for stable operation of the blocking generator, it is necessary to introduce in such a circuit an additional bias battery in the emitter or base circuit. The duration of the leading front of the pulse depends substantially on the time

Card : 2/4

BERESTOVSKIY, G.N.

I-8

USSR / Radiophysics. Application of Semiconductors.

Abs Jour : Ref Zhur - Fizika, No 5, 1957, No 12600

Author : Senatorov, K. Ya., Berestovskiy, G.N.

Inst : Physics Faculty, Moscow State University, USSR

Title : Analysis Processes in a Transistorized Blocking Generator

Orig Pub : Radiotekhn. i elektronika, 1956, 1, No 5, 654-669

Abstract : Using a grounded-emitter circuit as an example, an analysis is made of the physical processes in a blocking generator. With this, the total cycle of oscillation is broken up into the following four stages: recharging the capacitor, formation of the leading front of the pulse, formation of the peak of the pulse and formation of the trailing front of the pulse. This makes it possible to employ at all stages, with the exception of the stage where

Card : 1/4

L 13804-66

ACC NR: AP6001171

circuit are the same and are not dependent on pulse duration. In an axon the initial potential difference value is many times lower than the potential difference for circuit breaking and the latter value depends on pulse duration. Apparently, upon closer examination many more such disparaties can be found between the electric model and an axon. All these data indicate that the electric model simulates only the basic functional properties of a nerve fiber and structurally is quite different. Orig. art. has: 5 figures.

SUB CODE: 06/ SUBM DATE: 30Mar64/ ORIG REF: 002/ OTH REF: 006

6C

Card 2/2

L 13804-66 EWT(1)/FS(v)-3 SCTB DD

ACC NR: AP6001171 SOURCE CODE: UR/0217/65/010/005/0801/0804

AUTHOR: Berestovskiy, G. M.

ORG: Physics Department of Moscow State University im. M. V. Tomonosov (Fizicheskiy fakul'tet Moskovskogo gosudarstvennogo universiteta)

TITLE: Characteristics of an electric model of a nerve fiber under fixed potential conditions

SOURCE: Biofizika, v. 10, no. 5, 1965, 801-804

TOPIC TAGS: electrophysiology, electric potential nerve fiber, anatomic model, test cell

ABSTRACT: The characteristics of a nerve fiber electric model were studied by oscillogrophy and compared to literature data for axons. The electric model representing an isolated cell did not include longitudinal currents so that the nerve fiber could be investigated under fixed potential conditions. The first part of the V curves for the model and axons coincides. However, with higher values, the curves do not coincide because of the ventilating properties of an axon's membrane. This may be corrected in the electric model by including a resistor. In the model the potential difference values for closing and breaking of a

Card 1/2

UDC: 577.37

BERESTOVSKIY, G.G.

Strip arrangement of field crops. Zemledelie 25 no.9:78-84 S '63.
(MIRA 16:9)

1. Pavlodarskaya sel'skokhozyaystvennaya opytnaya stantsiya.
(Strip cropping)

BERESTOVSKIY, A., prepodavatel'

Models of measuring instruments. Prof.-tekh. obr. 18 no.9: 24-25 S '61. (MIRA 14:11)

1. Tekhnicheskoye uchilishche No.2, g. Sumy.
(Measuring instruments—Models)

ROMANOVA, L.V., kand.biol.nauk; BERESTOVSKAYA, S.S.

New indices for the quality evaluation of sunflower seeds.
Masl.-zhir.prom. 28 no.2:12-14 F '62. (MIRA 15:5)

1. Vsesoyuznyy nauchno-issledovatel'skiy institut zhirov.
(Sunflowers)

GOLDOVSKIY, A.M., doktor tekhn.nauk; BERESTOVSKAYA, S.S.

Proteic and nonproteic nitrogen-containing substances of flaxseed, and changes in proteins taking place during production. Masl.-zhir. prom. 27 no. 4:22-25 Ap '61. (MIRA 14:4)

1. Vsesoyuznyy zaochnyy institut pishchevoy promyshlennosti.
(Flaxseed)

APPROVED FOR RELEASE: 06/23/11: CIA-RDP86-00513R000204800029-6

GOLDOVSKIY, A.M., doktor tekhn.nauk; BERESTOVSKAYA, S.S.

Mucilage and other carbohydrates of flax seeds, and their behavior under industrial conditions. Masl.-zhir.prom. 27 no.3:21-26 Mr '61. (MIRA 14:3)

1. Vsesoyuznyy zaochnyy institut pishchevoy promyshlennosti (for Goldovskiy).

(Mucilage) (Flaxseed)

1ST AND 2ND ORDERS

PROCESSES AND PROPERTIES INDEX

CA

11d

Potassium compounds in plants. A. M. Goldovskii and S. S. Berestovskaya. *Doklady Akad. Nauk S.S.S.R.* 60, 81-4(1940).—Extn. of seeds or various parts of sunflower by Et_2O, EtOH, and H_2O followed by evapn. and ashing of the exts. was used to est. the amt. of bound K. Ripe seeds contain almost no K compds. sol. in Et_2O or EtOH; hence lipide K derivs. are substantially absent. Only 0.01% K is found in Et_2O exts. of leaves and stems in adult plants, but the value rises to 0.11% at the period of full blooming. Aq. exts. of ripe seeds contain 0.43% K while seeds in the process of ripening give values about 0.84%, and leaves of adult plants give 2.34% K while the stems give 2.80% K in the ext. EtOH exts. of all specimens give low K values: 0.03-0.13%. The K content is apparently distributed among several substances, as part of K in the aq. exts. can be pptd. by $Pb(OAc)_2$, and the remainder remains in soln. The nature of the K-contg. substances is not clear. G. M. Kosolapoff

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

SHKOL'NIK, L.M., kand. tekhn. nauk; BERESTOVOY, Ye.I., inzh., retsenzent; SARANTSEV, Yu.S., inzh., red.; KHITROVA, N.A., tekhn. red.

[Increasing the strength of the axles of the rolling stock] Povyshenie prochnosti osei zheleznodorozhnogo podvizhnogo sostava. Moskva, Izd-vo "Transport," 1964. 223 p. (MIRA 17:3)

SHAROV, I.F., kand. tekhn. nauk; KUZNETSOVA, V.N., inzh.; KUCHUK-YATSENKO, S.I., kand. tekhn. nauk; VOROB'YEV, A.A., inzh.; BUL'BA, T.G., inzh.; DOTSENKO, V.Ye., kand. tekhn. nauk, retsenzent; DOTSENKO, V.Ye., retsenzent; SHIYANOV, I.A., inzh., retsenzent; BERESTOVOY, Ye.I., inzh., red.; KHITROVA, N.A., tekhn.red.

[Equipment for rail welding] Oborudovanie dlia svarki rel'sov. [By] I.F.Sharov i dr. Moskva, Transzheldorizdat, 1963. 266 p. (MIRA 17:1)

MIKLASHEVSKIY, Sergey Nikolayevich, inzh.; OSIPOV, Konstantin Dmitriyevich, inzh.; BERESTOVOY, Ye.I., inzh., red.; BOBROVA, Ye.N., tekhn. red.

[Use of nylon parts for locomotives] Primenenie kapronovykh detalei na parovozakh; opyt depo Gomel' Belorusskoi zheleznoi dorogi. Moskva, Vses. izdatel'sko-poligr. ob"edinenie M-va putei soobshcheniia, 1961. 50 p. (MIRA 14:8)
(White Russia—Locomotives) (Nylon)

KIYAN, Dmitriy Moiseyevich, inzh.; BERESTOVOY, Ye.I., inzh., red.;
KHITROV, P.A., tekhn.red.

[Handbook for welders repairing locomotives] Spravochnik svarshchika po remontu lokomotivov. Moskva, Gos.transp. zhel-dor.izd-vo, 1959. 335 p. (MIRA 12:6)
(Locomotives--Maintenance and repair) (Welding)

SHEPELEV, Vasiliy Nikolayevich; OBUKHOV, Aleksandr Vasil'yevich; BERESTOVOV, Ye.I., inzh., retsenzent; ABRAGAM, S.R., inzh., red.; BOBROVA, Ye.N., tekhn.red.

[Welding and building-up of rails and railroad frogs] Svarka i naplavka rel'sov i krestovin. Moskva, Gos.transp.zhel-dor. izd-vo, 1959. 179 p. (MIRA 13:2)
(Railroads--Rails--Welding)
(Railroads--Maintenance and repair)

APPROVED FOR RELEASE: 06/23/11: CIA-RDP86-00513R000204800029-6

SOV/137-58-11-22616

The Effect of Welding Stresses on the Strength of Metal Structures

structural members operating under compression; the possibilities and methods of utilizing WS for purposes of improving the durability of welded structures, etc.

V. K.

Card 3/3

The Effect of Welding Stresses on the Strength of Metal Structures

SOV/137-58-11-22616

Institute for Machine Building and Industrial Structures), and others. A summary of the results of the employment of welding in structural and machine-building fields is presented. Postulates are formulated for the following topics: The effect of residual WS on the strength of structural members manufactured from plastic material and being in a ductile or brittle state; the effect of the WS on fatigue strength of structural elements; the role of subsequent heat treatment of welded structures. It is noted that, under certain conditions, the residual WS may lower the local or the over-all resistance to buckling of welded members operating under compression (at certain cross-sectional shapes, flexibility values, and properties of the material); however, the investigations performed do not furnish sufficient data to evaluate quantitatively the degree of reduction in the over-all resistance to buckling resulting from various factors. The following theoretical investigations were outlined at the symposium for the future: The effect of the stress-strain and structural state of the metal in welded structures on the process of its transition into the brittle state; the effects of the nature of the field of WS and of the scale factor on the static and fatigue strength characteristics of welded structures; the effect of the WS on the sensitivity to stress concentrations and the durability of welded structures particularly of structures made of low-alloy steel; the effect of WS on corrosion resistance of welded joints; the effect of the WS on the carrying capacity of

Card 2/3

SOV/137-58-11-22616

Translation from: Referativnyy zhurnal. Metallurgiya, 1958, Nr 11, p 114 (USSR)

AUTHOR: Berestovoy, Ye. I.

TITLE: The Effect of Welding Stresses on the Strength of Metal Structures (O vliyanii svarochnykh napryazheniy na prochnost' metallicheskikh konstruktsiy)

PERIODICAL: Byul. tekhn.-ekon. inform. M-vo putey soobshch. SSSR. Nauchno-tekhn. o-vo zh.-d. transp., 1957, Nr 10 (24) pp 93-96

ABSTRACT: The problem of the effect of welding stresses (WS) on the strength of metal structures was examined at the June 1957 conference of the coordinating committee of the Metallurgy Institute of the USSR Academy of Sciences for scientific-research work in the field of welding. The 14 reports discussed dealt with the results of experimental and theoretical work carried out by the Institute for Electrical Welding im. Ye. O. Paton, the LPI (Leningrad Polytechnic Institute im. Kalinin), the LKI (Leningrad Shipbuilding Institute), the MVTU im. Baumana (Moscow Higher Technical School im. N. Ye. Bauman), the MIIT (Moscow Institute of Railroad Engineers im. I. V. Stalin), the TsNIIMPS (Central Scientific Research

Card 1/3

Berestovoy, Ye. I.

NOVIKOV, Vladimir Nikolayevich; IVANOV, Georgiy Petrovich; SAVUKOV, Vladimir Pavlovich; BERESTOVOY, Ye.I., inzhener, redaktor; BOBROVA, Ye.N., tekhnicheskiy redaktor

[Electric spark hardening of locomotive parts; practices of the Moscow depot of the Moscow-Kursk-Donbass railroad] Elektroiskrovoe uprochnenie detalei parovozov; opyt depo Moskva Moskovsko-Kursko-Donbasskoi dorogi. Moskva, Gos.transp.zhel-dor.izd-vo, 1957. 50 p. (MLRA 10:7)

(Locomotives--Repairs) (Electric spark)

Sorestovich, P. S.

[illegible]